State of California

Business, Transportation and Housing Agency

Memorandum

To: District Directors

Date: September 8, 1998

Attention: District Division Chiefs for Planning, Design, and Traffic Operations

From: **DEPARTMENT OF TRANSPORTATION**
Design and Local Programs
Mail Station 28

Subject: Design Information Bulletin 80 – Roundabouts

The attached Design Information Bulletin (DIB) 80 supersedes the memorandum dated November 18, 1993 regarding the use of roundabouts on the State highway system. The purpose of DIB 80 is to provide guidance on appropriate applications, site requirements, geometric elements, and traffic analysis.

Neither Caltrans nor ASSHTO currently maintains standards for the design of roundabouts. Until design standards are adopted by Caltrans, all proposals for roundabouts on the State highway system shall be conceptually approved by the Project Development Coordinator prior to the approval of the Project Study Report or other project initiation document. The conceptual approval will be based on whether the proposal conforms with the general concepts contained in DIB 80.

It is recommended that copies of DIB 80 be distributed to all Project Engineers. A copy is also available through the Design Program internet homepage (www.dot.ca.gov/hq/oppd) under the DIB website.

If you have any comments or require additional information, please contact your Project Development Coordinator or Geometric Reviewer.

ORIGINAL SIGNED BY

ROBERT L. BUCKLEY
Program Manager
Design and Local Programs

Attachment

DESIGN INFORMATION BULLETIN NUMBER 80

California Department of Transportation
Design and Local Programs
Office of State Geometric Design Standards

ROUNDABOUTS

Approved By:

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September 8, 1998

I. BACKGROUND

The modern roundabout is a type of circular intersection that has been successfully implemented in Europe and Australia over the past few decades. Despite the approximately 35,000 roundabouts in operation around the world, there are fewer than 50 that exist in the United States. Until recently, roundabouts have been slow to gain support in this country. The lack of acceptance can generally be attributed to the negative experience with traffic circles or rotaries built in the earlier half of the twentieth century. Severe safety and operational problems caused these traffic circles to fall out of favor by the 1950's. However, substantial progress has been achieved in the subsequent design of circular intersections, and a modern roundabout should not be confused with the traffic circles of the past.

The modern roundabout is defined by two basic principles that distinguish it from a nonconforming traffic circle:

1. Roundabouts follow the "yield-at-entry" rule in which approaching vehicles must wait for a gap in the circulating flow before entering the circle, whereas traffic circles require circulating vehicles to grant the right of way to entering vehicles.

2. Roundabouts involve low speeds for entering and circulating traffic, as governed by small diameters and deflected entrances. In contrast, traffic circles emphasize high-speed merging and weaving, made possible by larger diameters and tangential entrances.

In giving priority to entering vehicles, a traffic circle tends to lock up at higher volumes. The operation of a traffic circle is further compromised by the high speed environment in which large gaps are required for proper merging. These deficiencies have been corrected with the modern roundabout.

The number of roundabouts constructed in the U.S. is relatively small, but those that are currently in operation have been reported to be performing favorably in terms of shorter delays, increased capacity, improved safety, and improved aesthetics. The roundabouts have resulted in an overall reduction in the number and severity of accidents, despite the initial concern that lack of familiarity with this type of intersection would lead to driver confusion.

II. CONCEPTUAL APPROVAL

Neither Caltrans nor AASHTO has maintained current guidelines for the design of roundabouts. **Until design standards for roundabouts are adopted by Caltrans, all proposals for roundabouts on the State highway system shall be conceptually approved by the Project Development Coordinator prior to the approval of the Project Study Report or other project initiation document.**

The conceptual approval will be based on whether the proposal conforms with the general concepts contained in this Design Information Bulletin. The purpose of this document is to provide a basis for evaluating roundabout proposals, and it is not intended to contain the comprehensive information needed to complete a design. Proposed roundabouts should be discussed with the Project Development Coordinator, Geometric Reviewer and Traffic Liaison Engineer throughout the conceptual and design stages of the project.

After a number of roundabouts of variable capacities have been constructed statewide, a study will be conducted by the Office of State Geometric Design Standards to evaluate the effectiveness of the roundabout designs and to gather any information needed to adopt design standards. To assist in this effort, the district should notify the Project Development Coordinator as soon as any issue is raised regarding the safety and operation of an intersection at which a roundabout has been installed.

III. APPROPRIATE APPLICATIONS

Roundabouts may be constructed on the State highway system for the primary purpose of improving safety and operations at intersections. They should not be considered for reasons of traffic calming or aesthetics, although such applications may be acceptable on facilities under other jurisdictions. Examples of appropriate uses for roundabouts on State facilities are as follows:

- Improvement of Intersection Capacity

When considering methods to increase the capacity of an intersection, the use of a roundabout may be analyzed as an alternative to stop signs or traffic signals. With conventional types of traffic controls, only alternating streams of vehicles are permitted to proceed through the intersection at one time, causing a loss of capacity to occur when the intersection clears between phases. In contrast, the only restriction on entering a roundabout is the availability of gaps in the circulating flow. The slow speeds within the circle allow drivers to safely select a gap that is relatively small. By allowing vehicles to enter simultaneously from multiple approaches using short headways, a possible advantage in capacity can be achieved with a roundabout. This advantage becomes more prominent when the volumes of left or right turning movements are relatively high.

- Reduction of Queue Storage Requirements

Roundabouts can produce operational improvements in locations where the space available for queuing is limited. Roads are often widened to create storage for vehicles waiting at red lights, but the reduced delays and continuous flows at roundabouts allow the use of fewer lanes between intersections. Possible applications may be found at existing diamond interchanges, where high left turn volumes can cause signals to fail. By constructing a pair of roundabouts at the ramp intersections, capacity improvements to the interchange can be accomplished without the costly requirement of widening the structure to carry additional lanes over or under the freeway.

- Accommodation of Unusual Intersection Geometries

Conventional forms of traffic control are often less efficient at intersections with a difficult skew angle, a significant offset, an odd number of approaches, or close spacing. Roundabouts may be better suited for such intersections, because they do not require complicated signing or signal phasing. Their ability to accommodate high turning volumes make them especially effective at "Y" or "T" junctions. Roundabouts may also be useful in eliminating a pair of closely spaced intersections by combining them to form a multi-legged roundabout.

- Reduction of Accidents

At some locations, a roundabouts can provide a possible solution for high accident rates by reducing the number of conflict points at which the paths of opposing vehicles intersect. For example, over half of the accidents at conventional intersections occur when a driver either (1) misjudges the distance or speed of approaching vehicles while making a left turn, or (2) causes a right angle collision after violating a red light or stop sign. Such accidents would be eliminated with a roundabout, where left turns and crossing movements are prohibited. Furthermore, collisions at roundabouts would involve low speeds and low angles of impact, and therefore, would be less likely to result in serious injury.

IV. SITE REQUIREMENTS

The following requirements should be considered when determining whether a proposed site is suitable for a roundabout:

- Geometric Design

Roundabouts should be considered only in areas that can accommodate an acceptable outside diameter and other appropriate geometric design elements (see Section V). To provide adequate sight distance for approaching drivers to perceive the layout of the intersection, the roundabout should be preferably located either on level terrain or at the bottom of a sag vertical curve. The topography should also allow the circle of the roundabout to be constructed on a flat plateau to provide visibility within the intersection.

- Capacity Limitations

For proposed roundabout sites, an analysis of traffic volumes and turning movements should be conducted to determine whether the roundabout would carry more capacity than another form of traffic control or operational improvement (see Section VI).

Because roundabouts have only begun to appear in the U.S., there is a lack of empirical data regarding the volume at which a roundabout begins to break down. Until further data is available, roundabouts on the State highway system should be considered only at intersections where volumes generally do not exceed 5000 vehicles per hour. Regardless of whether the proposal involves a new facility or an operational improvement, the design of a roundabout should be based on estimated traffic 20 years after the completion of construction.

- Adjacent Intersections

Consideration should be given to the interactive effects between a proposed roundabout and the adjacent intersections. Roundabouts are not suitable in areas with a coordinated traffic signal system, because such systems break down when the progression of platoons is disrupted by the unregulated movement of a roundabout. Conversely, a roundabout should not be constructed at a location where the flow of vehicles leaving the intersection would be obstructed by queues from downstream traffic controls.

- Balanced Entry Volumes

Roundabouts may not be effective at intersections where entry flows are unbalanced. When the volume on the major road is much heavier than that on the minor road, the equal treatment of approaches may cause undue delay to the major road. Also, if the major road carries a heavy stream of through-traffic, the lack of adequate gaps in the dominant flow may prevent the minor flow from entering the roundabout.

- Pedestrian and Bicycle Traffic

Additional assessment is warranted prior to constructing roundabouts in areas where pedestrian or bicycle activity is expected. With the absence of conventional crossing controls, many pedestrians do not perceive roundabouts to be safe. Despite this perception, accident records indicate that with the use of proper design elements, a pedestrian is at least as safe at a roundabout as at a conventional intersection. However, the safety record for bicyclists appears to be more problematic. Multi-lane roundabouts should not be considered at locations with existing bicycle activity unless an acceptable alternative can be provided for routing bicycle traffic through the area. The safety of bicyclists begin to deteriorate as roundabouts increase in size and speed.

V. GEOMETRIC DESIGN ELEMENTS

There is no uniform design guidance in the U.S. for modern roundabouts. However, the Federal Highway Administration is planning to develop guidelines within the next two years, and information on roundabouts will also be introduced in the next edition of AASHTO's Policy on Geometric Design of Highways and Streets. The design practices currently used in this country are generally based on either the British or the Australian guidelines.

The basic principle of roundabout design is to restrict the operating speed within the intersection by deflecting the paths of entering and circulating vehicles. Safety and capacity benefits can be fully achieved only if vehicles are physically unable to traverse the roundabout at speeds higher than approximately 40 km/h. The major elements of a roundabout are shown in Figure A and are described as follows:

- Inscribed Circle: The diameter of the inscribed circle may range between 15 m and 100 m. A minimum diameter of 37 m is required for roundabouts on the State highway system, because smaller circles do not adequately accommodate truck movements. However, the safety advantages of a roundabout may begin to diminish when the diameter of the inscribed circle exceeds 75 m.

- Circulatory Roadway: The width of the circulatory roadway depends mainly on the number of entry lanes and the radius of vehicle paths. The roadway must be at least as wide as the maximum entry width, and lane lines within the circle should not delineated. The pavement may be either crowned or sloped to one side, depending on the need to facilitate drainage or minimize adverse crossfalls for vehicle paths.

- Central Island: The central island is usually delineated by a raised curb, and its size is determined by the width of the circulatory roadway and the diameter of the inscribed circle.

- Truck Apron: A truck apron may be needed on smaller roundabouts to accommodate the wheel path of oversized vehicles. The apron is usually designed as a mountable portion of the central island.

- Splitter Island: This splitter island is placed within the leg of a roundabout to separate entering and exiting traffic. It is usually designed with raised curb to deflect entering traffic and to provide a refuge for pedestrian crossings.

- Bypass Lane: A bypass lane may be warranted for heavy right turn volumes.

- Pedestrian Crossing: The location of pedestrian crossing is generally recommended to be one to three vehicle lengths behind the yield line. Bringing crossings closer to the circle would reduce roundabout capacity, while placing them further away would expose pedestrians to higher speeds.

- Approach Width: This approach width refers to the half of the roadway that is approaching the roundabout.

- Departure Width: This departure width refers to the half of the roadway that is departing the roundabout.

- Entry Width: The entry width is the perpendicular distance from the right curb line of the entry to the intersection of the left edge line and the inscribed circle.

- Exit Width: The exit width is the perpendicular distance from the right curb line of the exit to the intersection of the left edge line and the inscribed circle.

- Flare: A flare may be used to increase the capacity of a roundabout by providing additional lanes at the entry. Because flared entries tend to increase the potential for accidents, they should be used only when required by traffic volumes.

- Entry Angle: To provide the optimum deflection for entering vehicles, the angle of entry should be approximately 30 degrees. Smaller angles reduce visibility to the driver's left, while larger angles cause excessive braking on entry and a resulting decrease in capacity.

- Entry Radius: The entry radius is the minimum radius of curvature measured along the right curb at entry. The practical entry radius is approximately 20 m. Smaller radii may decrease capacity, while larger radii may cause inadequate entry deflection.

- Exit Radius: The exit radius is the minimum radius of curvature measured along the right curb at exit. The desirable exit radius is approximately 40 m.

VI. CAPACITY ANALYSIS

There are two approaches to calculating the capacity of a roundabout. The British method involves an empirical formula based on measurements at saturated roundabouts, whereas the Australian method uses an analysis based on gap acceptance. A draft update of the Highway Capacity Manual (HCM) includes a procedure for determining the capacity of single-lane roundabouts using the gap acceptance approach. For analyzing multi-lane roundabouts, the draft HCM suggests the use of software programs, but no specific program is mentioned. It is recognized that there are advantages to using empirical models to develop relationships between geometric design characteristics and roundabout performance. However, given the current lack of field data in the United States, the draft HCM recommends using the analytical approach.

Although both approaches are currently acceptable, the fundamental differences between the empirical and analytical methods may sometimes produce inconsistent results. The two methods are described as follows:

- Empirical (British) Method

In the British method, the capacity formula is based on the relationship between entry capacity and various geometric parameters. For example, the capacity of each approach to a roundabout decreases linearly as the entry angle increases. Other parameters include entry width, approach width, entry radius, and inscribed circle diameter. Two computer software packages commonly used to calculate capacities, queues, and delays in accordance with the British formula are ARCADY (Assessment of Roundabout CApacity and DelaY) and RODEL (ROundabout DELay). Statistical tests have been performed to confirm the suitability of the geometric parameters used to predict capacity, and the output of both computer programs have been verified through direct field observations.

- Analytical (Australian) Method

In the Australian method, the capacity of a roundabout is calculated using a traditional gap acceptance approach that is similar to the process described in the HCM for analyzing two-way stop-controlled intersections. It is assumed that drivers need a minimum "critical gap" in the circulating flow before entering the roundabout. As the available gaps become larger, more than one driver can enter with subsequent headways equal to the "follow-up time". The capacity formula calculates the capacity of each approach as a function of the circulating flow, the critical gap, and the follow-up time. SIDRA (Signalized and unsignalized Intersection Design and Research Aid) is a the computer software package commonly used for predicting the performance of roundabouts by applying the gap-acceptance methodology.

VII. REFERENCES

A recommended reference for general information on roundabouts is the National Cooperative Highway Research Program Synthesis 264, "Modern Roundabout Practice in the United States". Additional reference material is available through the Geometric Reviewer, and information on ordering the appropriate capacity analysis software can be obtained from the Traffic Liaison Engineer.

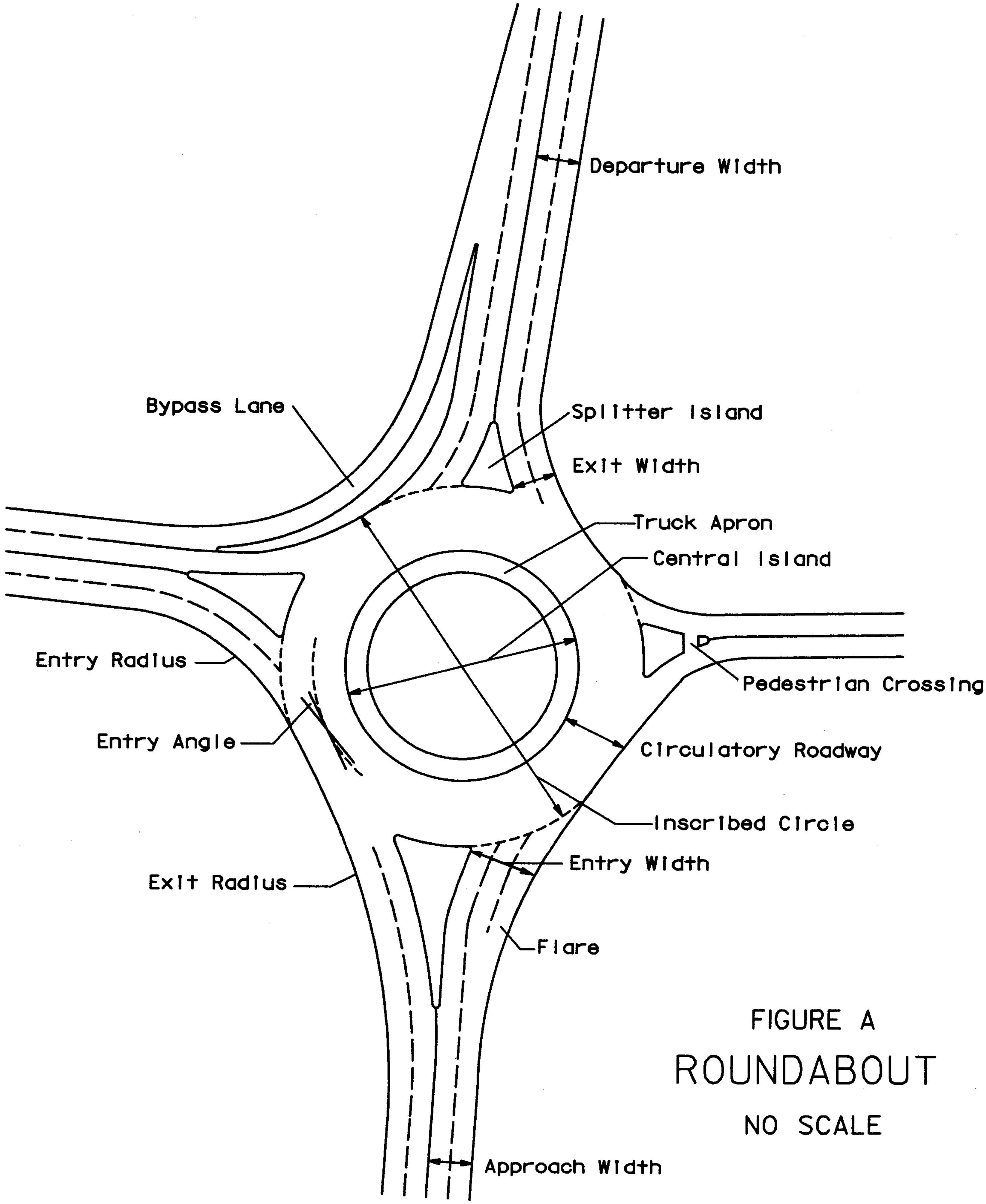

FIGURE A

ROUNDABOUT

NO SCALE

bc: RColeman
HBenouar
RBuckley
AGlen
JChampa
TCraggs
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